Dynamic Linkages between Prices and Imports for Japanese Frozen Tuna

Abstract

VAR models have been used to describe the dynamic relationships among market price, Japanese harvest, import-from-Taiwan, and import-from-Korea for frozen Big-Eye tuna and Yellow-Fin tuna markets in Japan. It is found that tuna imports from South Korea exert more significant effects on Japan market prices than import-from-Taiwan.

1. Introduction

Japan is the largest producer of tuna in the world. However, she relies on import for both "fresh" and "frozen" tuna to meet her domestic demand. Although the demand for tuna can be divided into fresh and frozen, it is frozen tuna has been imported the most. Among the imported frozen tuna, Thunnus obesus (Big-Eye tuna) and Thunnus albacares (Yellow-Fin tuna) are the two major categories. The amount of frozen Big-Eye tuna and frozen Yellow-Fin tuna imported has increased from 84,703 metric tons in 1981 to the peak of 273,399 metric tons in 1993. The harvest of Taiwan's and South Korean ultra low temperature longline fishing vessels are the major sources of imported frozen Big-Eye tuna and frozen Yellow-Fin tuna. Frozen Big-Eye and Yellow-Fin are mainly used to process household-type sashimi that is available to consumers in supermarkets for family consumption. Household-type sashimi is less expensive than the one made from fresh tuna, which is available to consumers in fine restaurants.

The market shares of Taiwan's supply in frozen Big-Eye tuna market of Japan has increased from 8% in 1981 to 23% in 1994, and from 4% in 1981 to 43% in 1994 (57% in 1993) for frozen Yellow-Fin tuna (Japan Tariff Association). The market share of South Korean products in Big-Eye market has decreased from 27% to 17%, and from 24% to 12% in Yellow-Fin market. The market shares of Japanese harvest has decreased from 61% to 39% for Big-Eye tuna, and from 63% to 19% (15% in 1993) for Yellow-Fin tuna during the same period. As such, Japanese fishermen often worry that increasing imports from Taiwan could deteriorate the market prices. A bilateral arrangement for regulatory tuna imports is negotiated by representatives of Japanese and Taiwan's tuna producers associations in order to reduce the impact of the increasing market shares of import-from-

Taiwan on Japanese prices. For instance, the import quota of total Taiwan's exports to Japan is set at 99,000 metric tons for year after 1994. Taiwan's tuna deep-sea longline fisheries have been an important part of her fishery industry. Compared to Taiwan's deep-sea fishery, the tuna fishery took about 50% of the value before 1991. Recently, the ratio increased to 75% in 1993. Although the import quota currently does not constraint the quantities of Taiwan′s exports to Japan, it definitely limits the future development of Taiwan's tuna industry.

Japanese, Taiwan's and South Korean longline tuna fleets fish in the same fishing grounds and catch the same tuna species due to the habit of Big-Eye and Yellow-Fin. However, Japanese vessels tend to catch more Big-Eye than Yellow-Fin, while Taiwan's and South Korean vessels tend to fish more Yellow-Fin than Big-Eye. Although Japanese, Taiwan, and South Korean tuna fleets land their products at the Yaizu port where is one of the largest wholesale entry points in Japan, Japanese products are usually sold in wholesale markets where prices are reached by auction procedure (Bose and McIlgorm, 1996). The products of Taiwan and South Korea are sold to trading companies at prices determined by buyers. Accordingly, impacts of import-from-Taiwan on Japanese tuna prices may not exist.

This study attempts to assess the impact of frozen tuna imports on Japan market prices, with special reference to the effect of import-from-Taiwan. The approach used in this study is Vector Autoregression (VAR). The approach of VAR, developed by Sims (1980), is to estimate a multi-equation model with the same set of lagged dependent variables. The economic relationships between endogenous variables and exogenous variables in the model are determined by data itself. Hence, it can be viewed as a flexible approximation to the reduced form of a correctly specified but unknown dynamic structure. In estimating the VAR model, present paper applies error correction method to justify cointegration which usually occur among economic time series.

The next section describes the method of modeling a VAR and the error correction method. Following the data and the estimation are presented. The impacts of quantity variables on prices are evaluated by decomposing forecast error variances of price variables in the forth section. The final section discusses the implications of the results and concludes the paper.

2. VAR Model

Assuming all of the variables are endogenous, a VAR model is given as follows:

$$Y_{it} = \beta_{i0} + \sum_{i=1}^{m} \sum_{j=1}^{p} \beta_{ij} Y_{it-j} + \in_{1t} \qquad (1)$$

where Y_{it} stands for observations on the m series at time t, p represents the number of lags for all endogenous variables, β's are parameters to be estimated, and ε is the error term. Bose and McIlgorm (1996) find that Big-Eye and Yellow-Fin could be appreciated as substitute to each other. To take this substitutability into account, Big-Eye and Yellow-Fin markets should be examined at the same time. Therefore, ten endogenous variables are involved in the VAR model: Big-Eye price, Yellow-Fin price, Japanese Big-Eye production, Big-Eye imported from Taiwan, from South Korea, from other countries (mainly from Indonesia), and Japanese Yellow-Fin production, Yellow-Fin imported from Taiwan, from South Korea, and from other countries.

Equation (1) can be estimated by OLS (Ordinary Least Squares) because the set of independent variables is the same in each equation. The only subjective judgement on the specification of VAR is to choose p, the lag length. Obviously, the number of lag must be long enough to completely describe the dynamic behavior of the studied system. However, the longer the lags are specified, the greater the numbers of parameter need to be estimated (Pindyck and Rubinfeid, 1991). To choose the lag length, Sims (1980) suggests the use of likelihood ratio tests. The procedure that tests a null lag length of p-1 against an alternative of p is to run two VARs over the same time period. The test statistic, LR is shown as:

$$LR = (T - C)\left[\log\left|\Sigma_{p-1}\right| - \log\left|\Sigma_{p}\right|\right] \qquad (2)$$

where T is the number of observations, C is number of coefficients in each equation of the system with lags of p, and Σ_{p-1} and Σ_{p} are the covariance matrices of residuals for lag length of p-1 and p, respectively. The test statistic is asymptotically distributed as χ^2 distribution with degrees of freedom equal to the number of restriction.

If each of the m endogenous variables is not stationary such as has a unit root, then their first differences have to be used in the VAR estimation. However, individual economic time series are not stationary, linear combinations of them can be stationary due to long-run equilibrium forces (Engle and Grager, 1987). When this happens the variables are co-integrated. The conventional VAR needs to include some error correction terms to account for short-term deviations from the long-term equilibrium relationship implied by the cointegration. The model for cointegration vectors can be shown as follows:

$$\Delta Y_{it} = \beta_{i0} + \sum_{i=1}^{m} \sum_{j=1}^{p} \beta_{ij} \Delta Y_{it-j} + \sum_{j=1}^{k} \pi_{ij} Y_{jt-1} + \in_{1t} \qquad (3)$$

Equation (3) is called vector of error correction (VEC) which resembles a VAR model in the first differences except for the presence of the lagged level of Y_{it}. Let Π be a m x k matrix of parameter π_{ij}. According to the rank of Π, there are three possibilities of interest: 1) Π is full rank, then endogenous variables are stationary and a VAR in level is an appropriate model; 2) Π has zero rank, then Π contains no long-run information and a VAR in differences is an appropriate model; 3) the rank of Π is a positive number k which is less than m, then Π contains information about the long-run relationship between endogenous variables and an VEC is an appropriate model . The number of cointegrated vector, k in the system can be determined by likelihood ratio test developed by Johansen (1991). The likelihood ratio test statistic of k versus k+1 is given by

$$-2\ln(Q) = -T\ln(1-\lambda_{k+1}) \qquad (4)$$

where T is the number of observations and λ is the ordered eigenvalue.

3. Data and Estimation

Monthly data on wholesale price and various quantity variables for the period from January1984 through December1994 are used in the estimation. The series of price is deflated by Wholesale Price Index (1990=100). The average price of Big-Eye tuna is 1027.7 yens per kilogram during the sample period, while 588.44 yens per kilogram for Yellow-Fin tuna. The difference between two prices is due to the quality of tuna species and preference of consumers. On average, prices of Big-Eye tuna are higher than Yellow-Fin tuna by 50%. All the testing and estimation processes are performed by using computer package EVIEWS 2.0.

Augmented Dickey-Fuller unit root test was first conducted for each individual series and the results are presented in Table 1. Tests are performed against two common alternatives: one consistent with fluctuations around a constant mean, the other with stationary fluctuations around a deterministic linear trend. Both tests were conducted for four-lag, eight-lag, and twelve-lag specifications to account for serial correlation in the error term. The hypothesis of unit root is not rejected for Big-Eye price, Yellow-Fin imported from Taiwan, and Yellow-Fin imported from South Korea. However, the rejection of unit roots in Big-Eye imported from Taiwan, South Korea, and other countries occur only under four-lag specification. The rejection of unit roots in Yellow-Fin prices occurs under eight-lag and twelve-lag specifications, while that for Japanese Big-Eye production, Japanese Yellow-Fin production and Yellow-Fin imported from other countries occur under four-lag and eight-lag specifications. Accordingly, all variables are treated as non-stationary and the first differences have to be used in the subsequent testing or estimation procedures.

The order of the VAR model has to be determined before testing co-integration of variables. Based on the Sims' likelihood ratio test statistics, eight-order specification is chosen for the VAR model. Table 2 reports the co-integration test results for the VAR model to determine the number of co-integration vectors present, based on the likelihood ratio procedure. Results ensure that there exist six co-integration vectors among the variables investigated. Thus, six error correction terms are included in the estimation of VEC.

4. Decomposition of Forecast Error Variance

The estimated VEC model is used to investigate the dynamic impacts of domestic and foreign supply on frozen tuna prices by decomposing the forecast error variances of each price series. Forecast error variance decomposition is conducted over a forty-eight period to assess the extent to which quantity variable affects tuna price over time. The procedure involves decomposing the forecast error variance of each endogenous variable into the part due to each of the shocks in the system. Since the VEC model is not a real reduced from of a structure model, each shocks in the system should be interpreted as an innovation to a specific VEC equation which reflect the error left unexplained by the equation (Liu, et al. 1993). If the movement of a specific quantity variable is important to the tuna price in question, then shocks in the equation pertaining to that quantity variable should account for a large proportion of the unexpected variation in the tuna price. Tables 3 and 4 present the results of the decomposition of forecast error variances for Big-Eye and Yellow-Fin price variables, respectively.

<u>Big-Eye Market</u>

Column 2 in Table 3 reports the percentage of the unexpected variations in the Big-Eye price contributed by a shock in Yellow-Fin price. Columns 3 to 6 report the percentages of the unexpected variations contributed by shocks in Big-Eye quantities of different origins. The impacts of shocks in the Yellow-Fin quantity variables on Big-Eye price are reported in columns 7 to 10.

Over 40% of unexpected variation in Big-Eye price are contributed by Big-Eye price variable itself, reflecting shocks in Big-Eye prices are very important to the movement of the Big-Eye price. The impact of Yellow-Fin prices on the unexpected Big-Eye price variation is insignificant in the first period but increases steadily over time. The result indicates a one-way causal relationship between Big-Eye and Yellow-Fin, which Big-Eye prices lead Yellow-Fin prices. This may be explained by that Big-Eye is superior to Yellow-Fin.

The shocks of all quantity variables account for 14.89% of the unexpected Big-Eye price variation at lag 2 but increases as the horizon is extended. The finding indicates that the impact of lagged Big-Eye price is very significant in short-term, while those of quantity variables tend to be delayed but increase over time. It seems that Big-Eye prices take some time to adjust in response to quantity variables. The impact of Big-Eye quantity accounts for12.68% of the unexpected Big-Eye price variation in the second period and it reaches the peak of 29.57% in the eighth period; compared with 2.21% and the peak of 33.81% in the forty-eighth period for Yellow-Fin production. The response of Big-Eye price to shocks in Yellow-Fin quantity is relatively more significant but slower than the response to shocks in Big-Eye quantity. The difference in the magnitude of impact and in the adjustment speed may be due to a differential in the dynamic linkage between the Big-Eye and Yellow-Fin markets. Further research in this area is in need to provide additional insight toward the multifarious dynamics of frozen tuna markets.

Finally, look into the impact of individual quantity variable on Big-Eye prices. The impact of Japanese Big-Eye production accounts for 10.18% of the unexpected Big-Eye price variation in the second period with a peak 22.5% in the forth period, but then decreases rapidly. The shock of Taiwan's Big-Eye exports to Japan reaches the peak of 10.88% in the forth period but then decreases rapidly. The impact of Big-Eye imported from South Korea is insignificant, while those of Yellow-Fin imported from South Korea tends to be delayed but increases quickly over time. As reported in columns 4 and 8, the impact of imports from Taiwan is modest for Big-Eye price.

Yellow-Fin Market

In Table 4, column 2 reports the percentage of the unexpected variations in the Yellow-Fin price contributed by a shock in Big-Eye price. Columns 3 to 6 report the percentages of the unexpected variations contributed by shocks in Big-Eye quantities of different origins. The impacts of shocks in the Yellow-Fin quantity variables on Yellow-Fin price are reported in columns 7 to 10.

The shock of Big-Eye price accounts for 41.49% of the unexpected Yellow-Fin price variation in the first period and decreases slowly over time. Nearly 40% of unexpected variation in Yellow-Fin price is contributed by Big-Eye price variable, reflecting shocks in Big-Eye prices are very important to the movement of the Yellow-Fin price. Obviously, if Big-Eye prices have been excluded from the model, at least part of the 40% impact would have been attributed incorrectly to a shock in Yellow-Fin prices.

Quantity variables exert a relatively more significant impact on Yellow-Fin price than they do on Big-Eye prices. For example, it accounts for 47.16% of the unexpected Yellow-Fin price variation in the first period and increases gradually over time. The shock of Big-Eye production accounts for less than 15% of the unexpected Yellow-Fin price variation at all studied horizons. The impact of Yellow-Fin production on Yellow-Fin price variation increases from 33% in the first period to 47% in the forth-eighth period. The impact of Japanese Yellow-Fin production exerts 8.06% of the unexpected Yellow-Fin price variation in the first period and increases over time, while those of imports from South Korea accounts for 12.55% of the unexpected Yellow-Fin price variation in the first period and increases slowly over time. As reported in columns 4 and 8, Taiwan's tuna exports to Japan exerts an insignificant impact on Yellow-Fin price. For example, it accounts for less than 7.5% of the unexpected Yellow-Fin price variation at all studied horizons. In general, it is found that the impact of Yellow-Fin imported from South Korea on Yellow-Fin prices is relatively more significant than other quantity variables.

5. Conclusions

This study assesses the impact of Taiwan's frozen tuna exports to Japan on market prices in order to provide notable evidence for Taiwan's interest groups to negotiate with Japanese. VAR models have been applied to time series of market price, Japanese harvest, import-from-Taiwan and import-from-Korea for frozen Big-Eye tuna and frozen Yellow-Fin tuna markets in Japan. In estimating the VAR model, current paper applies error correction method to justify cointegration which usually occur among economic time series. The estimated VAR model is used to investigate the dynamic impacts of domestic and foreign supply on frozen tuna prices by decomposing the forecast error variances of each economic series.

Results show that Big-Eye price shocks have a significant effect on Yellow-Fin prices, while the impact of Yellow-Fin price shocks on Big-Eye prices is insignificant. In general, it is found that the impact of Yellow-Fin imported from South Korea on tuna prices is relatively more significant than other quantity variables in long-term. The results highlight the need to consider price linkage between Big-Eye and Yellow-Fin in regulate tuna market.

Table 1. Augmented Dickey-Fuller Unit Root Test

	Four-Lag Model		Eight-Lag Model		Twelve-Lag Model	
Variables	Constant[a]	C &Trend[b]	Constant	C & Trend	Constant	C & Trend
JBP	-2.76	-3.45	-1.80	-2.61	-1.50	-2.49
JYP	-2.89	-2.88	-3.15*	-3.16	-3.22*	-3.55*
JBQ	-2.73	-3.80*	-1.77	-3.99*	-0.62	-3.45
TBQ	-2.45	-4.09*	-1.89	-3.34	-0.81	-1.83
KBQ	-4.23*	-4.40*	-2.68	-3.05	-1.63	-2.44
OBQ	-1.45	-3.96*	-1.18	-2.09	-1.09	-1.52
JYQ	-2.91*	-4.17*	-2.97*	-3.49*	-2.24	-2.11
TYQ	-1.64	-3.05	-1.22	-2.23	-1.46	-3.01
KYQ	-2.76	-2.94	-2.53	-2.74	-1.79	-2.30
OYQ	-3.24*	-3.18	-3.02*	-2.97	-2.30	-2.27

Note: Variable abbreviations are JBP (Big-Eye market price), JBQ (Japanese harvest of Big-Eye), TBQ (Big-Eye quantity imported from Taiwan), KBQ (Big-Eye quantity imported from South Korea), OBQ (Big-Eye quantity imported from other countries), JYP (Yellow-Fin market price), JYQ (Japanese harvest of Yellow-Fin), and TYQ (Yellow-Fin quantity imported from Taiwan), KBQ (Yellow-Fin quantity imported from Korea), OYQ (Yellow-Fin quantity imported from other countries).

[a] The regression equation includes constant only.

[b] The regression equation includes both constant and trend.

Superscript * denotes the rejection of the null hypothesis of a unit root at the 5% significance level.

Table 2. Johansen's Cointegration Test

H_0	Test statistic	Critical value (5%)
k = 0	548.18*	233.13
k≦1	392.93*	192.89
k≦2	275.96*	156.00
k≦3	182.61*	124.24
k≦4	115.10*	94.15
k≦5	73.85*	68.52
k≦6	43.74	47.21
k≦7	21.75	29.68
k≦8	6.09	15.41
k≦9	1.06	3.76

Note: k is the number of co-integrated vectors.

Table 3. Decomposition of Forecast Error Variances of Big-Eye Price (in Percentage)

Lag	JBP	JYP	JBQ	TBQ	KBQ	OBQ	JYQ	TYQ	KYQ	OYQ
1	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	83.66	1.46	10.18	0.01	1.83	0.66	0.99	0.14	0.11	0.97
4	64.04	3.89	22.50	2.44	1.25	0.74	1.36	2.20	0.32	1.28
8	47.79	5.44	13.54	10.88	1.54	3.61	4.20	4.87	3.22	4.92
12	49.25	4.16	8.13	7.14	3.60	3.82	10.11	3.77	6.81	3.22
16	48.22	6.15	7.03	5.23	3.04	3.89	10.89	3.62	9.54	2.38
20	45.05	6.24	6.12	4.81	2.67	4.02	9.47	3.43	14.16	4.03
24	45.22	6.97	5.41	4.21	2.66	3.74	9.99	3.73	12.70	5.36
36	42.17	10.23	4.81	3.34	2.28	3.49	8.56	3.10	13.77	8.25
48	41.90	10.24	4.62	3.66	3.38	3.39	8.18	2.97	12.73	9.93

Note: Variable abbreviations are as Table 1.

Table 4. Decomposition of Forecast Error Variances of Yellow-Fin Price (in Percentage)

Lag	JYP	JBP	JBQ	TBQ	KBQ	OBQ	JYQ	TYQ	KYQ	OYQ
1	11.33	41.49	4.55	3.61	2.34	3.34	8.06	2.92	12.55	9.79
2	11.59	41.19	4.56	3.67	2.40	3.42	8.06	2.93	12.50	9.69
4	11.74	41.02	4.65	3.63	2.41	3.47	8.08	2.91	12.36	9.73
8	11.34	40.85	4.77	3.93	2.41	3.60	8.49	3.17	12.08	9.37
12	10.73	41.15	4.43	3.79	2.27	3.68	9.73	3.33	12.39	8.50
16	10.84	39.82	4.32	3.58	2.16	3.93	10.48	3.13	13.95	7.80
20	10.93	38.89	4.14	3.45	2.08	3.96	10.37	2.97	15.64	7.58
24	11.12	38.70	4.03	3.40	2.05	3.90	10.37	2.93	15.95	7.55
36	11.80	38.25	3.99	3.32	2.07	3.75	10.21	2.87	16.19	7.55
48	11.87	38.19	3.95	3.23	2.01	3.66	10.12	2.92	16.49	7.57

Note: Variable abbreviations are as Table 1.

References

Association of Agriculture and Forestry Statistics (1996) Annual Statistics on Marketing of Fishery Products, Japan,

Bose, S. and A. McIlgorm. (1996) "Substitutability among Species in the Japanese Tuna Market: A Cointegration Analysis." Marine Resource Economics. 11(3), 143-55.

Engle, R. F. and C. W. J. Granger (1987) "Co-Integration and Error Correction: Representation, Estimation, and Testing." Econometrica, 55, 251-76.

Japan Tariff Association, Japan Exports & Imports Country by Commodity. Various issues.

Johansen, S. (1991) "Estimation and Hypothesis testing of Cointegration Vectors in Gaussian Vector Autoregressive Models." Econometrica 59, 1551-1580.

Liu, D. J. P.　J. Chung, and W. H. Meyers (1993) "The Impact of Domestic and Foreign Macroeconomic Variables on U.S. Meat Exports." Agri. And Reso. Econ. Rev. 210-221.

Pindyck, R. S. and D. L. Rubinfeld (1991) Econometric Models and Economic Forecasts. McGraw-Hill, Inc.

Sims, C. (1980) "Macroeconomics and Reality." Econometrica, 48:1-48.